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TECHNICAL SPECIFICATION

Recommendations for small renewable energy and hybrid systems for rural electrification –
Part 7: Generators

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FOREWORD

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- the subject is still under technical development or where, for any other reason, there is the future but no immediate possibility of an agreement on an International Standard.

Technical specifications are subject to review within three years of publication to decide whether they can be transformed into International Standards.

IEC 62257-7, which is a technical specification, has been prepared by IEC technical committee 82: Solar photovoltaic energy systems.

This document is based on IEC/PAS 62111; it cancels and replaces the relevant parts of IEC/PAS 62111.

This technical specification is to be used in conjunction with the future parts of this series as and when they are published.

The text of this technical specification is based on the following documents:

Enquiry draft	Report on voting
82/492/DTS	82/507/RVC

Full information on the voting for the approval of this technical specification can be found in the report on voting indicated in the above table.

This publication has been drafted in accordance with the ISO/IEC Directives, Part 2.

A list of all parts of IEC 62257 series, under the general title: *Recommendations for small renewable energy and hybrid systems for rural electrification,* can be found on the IEC website.

The committee has decided that the contents of this publication will remain unchanged until the maintenance result date indicated on the IEC web site under "http://webstore.iec.ch" in the data related to the specific publication. At this date, the publication will be

- transformed into an International standard;
- reconfirmed;
- withdrawn;
- replaced by a revised edition, or
- amended.

A bilingual version of this publication may be issued at a later date.

INTRODUCTION

The IEC 62257 series of documents intends to provide to different players involved in rural electrification projects (such as project implementers, project contractors, project supervisors, installers, etc.) documents for the setting-up of renewable energy and hybrid systems with a.c. voltage below 500 V, d.c. voltage below 750 V and power below 100 kVA.

These documents are recommendations

– to choose the right system for the right place;

– to design the system;

– to operate and maintain the system.

These documents are focused only on rural electrification, concentrating on but not specific to, developing countries. They must not be considered as all-inclusive to rural electrification. The documents try to promote the use of renewable energies in rural electrification; they do not deal with clean development mechanisms at this time (CO_2 emission, carbon credit, etc.). Further developments in this field could be introduced in future steps.

This consistent set of documents is best considered as a whole with different parts corresponding to items for safety, sustainability of systems and at the lowest life-cycle cost as possible. One of the main objectives is to provide the minimum sufficient requirements, relevant to the field of application, that is, small renewable energy and hybrid off-grid systems.

The purpose of this part of IEC 62257 is to provide project implementers with general information about generators and to highlight the main characteristics relative to the different technologies that can be used.

RECOMMENDATIONS FOR SMALL RENEWABLE ENERGY AND HYBRID SYSTEMS FOR RURAL ELECTRIFICATION –

Part 7: Generators

1 Scope

The purpose of this part of IEC 62257 is to specify the general requirements for generators (maximum power = 100 kVA) in decentralized rural electrification systems.

The aim is to point out the main items that must be considered when selecting, sizing, installing, operating and maintaining this equipment.

This technical specification is a general introduction followed by more specific documents dedicated to the generation technologies which are the most currently used in rural electrification projects.

2 Normative References

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

IEC/TS 62257-2:2004, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 2: From requirements to a range of electrification systems*

IEC/TS 62257-4, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 4: System selection and design*

IEC/TS 62257-5, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 5: Protection against electric hazards*

IEC/TS 62257-7-1, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-1: Generators – Photovoltaic arrays*

IEC/TS 62257-7-3, *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 7-3: Generating set – Selection of generating sets for rural electrification systems*

IEC/TS 62257-9-1[1], *Recommendations for small renewable energy and hybrid systems for rural electrification – Part 9-1: Micropower systems*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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1 To be published.

3.1
generator
apparatus that converts one form of energy into electricity

[IEC 61836, 3.3.25, modified]

3.2
dispatchable power system
power system where delivered electricity is available as scheduled

(ex: a fossil-fuelled engine-powered generator is dispatchable. A renewable energy generator is usually a non dispatchable power system)

[IEC 61836, 3.3.64, modified]

3.3
non-dispatchable power system
non-dispatchable system is resource dependent; power might not be available at a specified time

3.4
collective electrification system
small electric generating system and minigrid that supplies electricity to multiple consumption points from a single or multiple energy sources

[IEC 61836, 3.3.10]

3.5
individual electrification system
small electric generating system that supplies electricity to one consumption point, such as a household, usually from a single energy source

[IEC 61836, 3.3.32]

3.6
interface
boundary between two systems or the equipment facilitating the interconnection of two systems

3.7
genset
colloquial term meaning “engine-generator set” consisting of a fossil-fuelled engine coupled to an electric generator

[IEC 61836, 3.3.26]

3.8
microgrid
grid that operates at less than 100 kVA of capacity and is electrified by a micropower system

3.9
micropower system
generating system that produces less than 100 kVA through the use of a single source or a multi-source system

3.10
user installation
electrical installation located in the user’s house, powering the user’s appliances and connected to the interface with the microgrid

4 General

In an electrification system, a generator is a part of the energy production subsystem. Different architectures of energy production subsystems are provided in IEC/TS 62257-2 along with some recommendations for selecting the relevant energy production subsystems matching both sources and demand requirements. (IEC/TS 62257-2, Annex D).

An energy production subsystem may include one or several generators of the same technology or of different technologies (hybrid production). Recommendations to configure hybrid power systems are provided in IEC/TS 62257-9-1. According to the availability of the primary resource, the generators can be classified as dispatchable or non-dispatchable.

5 Generator boundaries

Figure 1 illustrates the position of the generator in an electrification system.

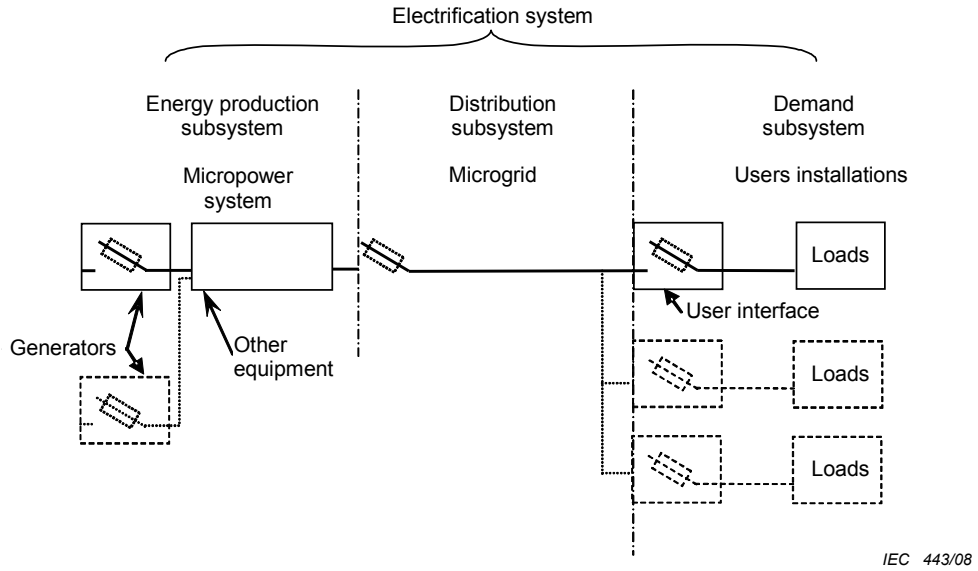

Figure 1 – General electrical configuration of a collective electrification system

NOTE 1 As explained in IEC/TS 62257-4, a collective electrification systems is composed of 3 parts as shown in Figure 1; an Individual Electrification System does not include a distribution subsystem, but could be powered by a micropower system.

NOTE 2 Micropower systems are addressed in IEC/TS 62257-9-1.

The generator embodies everything needed to produce electric power corresponding to the necessary characteristics of voltage, frequency, harmonics, power and consumption of the customers, according to the needed quality of service.

In the IEC 62257-7 series, “generator” means “installed generator”. Are included in a generator:

- The generator itself, able to produce electricity from a primary source of energy (sun, wind, fuel, water).
- The associated internal control devices.
- The associated protective devices.
- The associated connecting devices with other equipment of the micro power system (busbars, etc.).
- The necessary infrastructure and civil engineering.

6 Generators requirements

6.1 General requirements

When defining the generator characteristics the following “inputs” and “outputs” shall be taken into consideration as indicated in Table 1:

Table 1 – General inputs and outputs to be considered for generator specification

Input requirements (constraints)		Generator characteristics		Output requirements (results)
Primary energy resources (sun, wind, water flow/head, fuel)	▶	Technology Size Weight Volume Protection Housing Civil engineering Maintenance requirements Internal control	◀	Electrical performances (voltage, current, power, frequency)
Environmental conditions (air pressure/humidity/ temperature)				Safety (people, equipment)
Signals (start/stop, synchronization)				Environmental impacts (exhaust, heat, noise)
Regulations / Standards				
Assessment of energy demand				
Assessment of energy quality requirements				

6.2 Specific requirements for the different technologies

6.2.1 Input requirements

Table 2 gives examples of issues that have to be addressed concerning the site characteristics in order to assess whether the generator is relevant to the requirements of the General Specification.

Table 2 – Input requirements relative to the generator technology

Input requirements (constraints)	Issues to be addressed			
	PV array	Wind turbine	Genset	Micro hydro turbine
Resource availability	Only during daylight and variable according to the season	High short-term variability; seasonality and extreme conditions (storm)	Linked to site accessibility and local storage capabilities	Day and night availability; seasonality and extreme conditions (overflow)
Resource assessment	Possibility of extrapolation of existing data concerning a neighbouring area	Extrapolation of existing data requires the use of dedicated software and a thorough assessment of the site configuration	Easy evaluation of sourcing and of possibility of transportation and recycling drums	In most cases, no existing data available; on site measurement of flow and observation of seasonal variations

Table 2 *(continued)*

Input requirements (constraints)	Issues to be addressed			
	PV array	**Wind turbine**	**Genset**	**Micro hydro turbine**
Resource level	Production of a given array could vary by a factor of 4 depending on site solar irradiation and temperature characteristics	A minimum wind speed is required to start production Production is strongly dependant on wind resource, theoretically on a cubic law	Specific consumption (l/kWh) varies with load factor and altitude	A minimum water flow or head is required
Possibility to install the generator as close as possible to the energy utilisation	Yes, if room available	Not always practical The wind resource is dependant on the location In a few cases small wind turbines can be installed directly on roofs Consider also noise problems	Yes; but see environmental impact Consider also noise problems	Not always practical The location is dependant on the water resource
Room availability for installing the generator	The ratio surface / power installed is high for PV arrays compared to other generator Small PV array can be installed directly on roofs	Space for setting up include the stays installation and possibility to lay down the turbine for maintenance	The ratio surface / power is the smallest Additional space for fuel storage is needed	The infrastructure is very dependant of the technology and of the necessary head
Site characteristics to be considered	Shadowing	Roughness, obstacles, etc.	Accessibility for fuel transportation	Accessibility to the water resource
Civil engineering constraint level	Low to medium, depending on the configuration of the ground, the consistency of the soil, the quality of the roofs	Medium to high depending on the configuration of the ground, the consistency of the soil or the quality of the roof Depends on the size and technology of the wind turbine	Low	Could be high depending on the slope and width of the river
Needed operation skill	Low	Low, but high for maintenance operation	Low, but high for heavy maintenance operation	Low, but medium for maintenance operation
Operation constraints	Batteries storage or hybridation needed to adapt the production to the demand	Batteries storage or hybridation needed to adapt the production to the demand	To operate between 50 % and 80 % of the rated power to ensure the nominal lifetime of the engine Fuel storage needed	To adjust the settings of the turbine in relation to the available flow and the electricity demand

NOTE Different levels of accuracy to collect resources and demand data are given in IEC/TS 62257-4.

6.2.2 Output requirements

Table 3 highlights the issues that have to be solved for each type of generator regarding the different output requirement listed in the General Specification (GS).

Table 3 – Output requirements relative to the generator technology

Output requirements (results)	Issues to be solved			
	PV array	**Wind turbine**	**Genset**	**Micro hydro turbine**
Electrical performances (loads and quality of service)	Voltage forming needed (battery, hybridation) Storage to adapt production to demand Energy conversion needed if a.c. demand	Voltage and frequency regulation by an external mean Storage needed to adapt production to demand Energy conversion needed when using wind turbines for battery charging	Internal voltage and frequency regulation	Voltage and frequency regulation by flow or demand regulation Storage needed in some cases Energy conversion needed when using battery charging
Safety issues	Electrical Mechanical (wind effect on PV array)	Electrical Moving parts Mechanical (erection / laying down the machine)	Electrical Moving parts Heat Fire hazard	Electrical Moving parts Water pressure
Environmental impact	Visual Ground occupation Battery recycling (if battery storage)	Visual Noise Battery recycling (if battery storage)	Noise Soil pollution due to oil and fuel Air pollution due to exhaust Heat	Visual (especially due to the weir and the penstock, if any) Fauna and flora impact

Electrical performances shall be defined in order to supply the quality level as required in the GS of the project. Supply quality indicators are given in IEC/TS 62257-2, Annex C, Table 6.

Safety recommendations include general electrical safety requirements from IEC/TS 62257-5 (common to all generators) but attention shall be paid to the specific aspects related to each technology (mechanical hazards, moving parts, fire hazards, high temperature, etc.).

The design of the generator shall take into account the characteristics of the appliances to be supplied (e.g. a poor power factor implies the oversizing of the generator).

6.2.3 Specific requirements for different generator technologies

Specific requirements for different technologies are addressed in the following technical specifications as indicated in Table 4:

Table 4 – Specific generators requirements considered in the IEC 62257 series

Designation	IEC 62257 reference
PV array	IEC/TS 62257-7-1
Wind turbine	[a]
Generating set	IEC/TS 62257-7-3
Micro-hydro turbine	[b]
[a] Standard to be developed.	
[b] Standard to be developed.	

7 Generator design and sizing

Power and energy can be supplied by one or several combined generators.

The generator or a hybrid micropower system including several generators shall be sized and designed to provide the peak power and the energy required by the GS.

The main architectures of micropower systems are provided in IEC/TS 62257-2.

Several strategies may be developed to ensure both the satisfaction of customers and profitability of the project. The oversizing of the generator may increase the satisfaction of customers but can also endanger the profitability of the project. Attention shall be paid to the fact that for generating sets oversizing can also be a technical risk (refer to IEC/TS 62257-7-3).

In order to help optimizing the techno-economic calculations of systems, refer to IEC/TS 62257-4.

The GS requires a specified level of quality of supply for voltage and current supplied to the customer. Therefore, generators shall be selected, designed and sized in order to be able to provide the required level of quality. For that purpose, important parameters shall be taken in account such as the appliances to be powered, the length of the microgrid, the architecture of the micropower system (one or several generators, mix of technologies, storage, etc.).

8 Hybrid generation

Specific requirements for the combination of different generators in a micropower system are addressed in IEC/TS 62257-9-1.

Bibliography

IEC/TS 61836, *Solar photovoltaic energy systems – Terms, definitions and symbols*

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